~~SECRET~~

m-39886

CONFIDENTIAL

ENG-M8 -1246

Chief, Procurement Division, OL

ATTN : Contracting Officer

Chief, Engineering Staff, OC

19 November 1958

**Please Return To
Engineering Staff**

25X1

Contract NB-605,

REF : OL Memorandum 7 November 1958, Contractor's Letter, 27 October 1958

1. The subject contractor has requested approval for presentation of technical papers outlined in the attachments to the referenced letter at the 1959 IRE National Convention.

2. This office will concur with the presentation of papers covering "Log Periodic Feeds for Lens and Reflectors" (Task Orders 1 and 4), and "A New Concept in High Frequency Antenna Design" (Task Order 5). In presentation of these papers the contractor should be limited by the following conditions:

    (a)   The association of this Agency with the contract and the equipment is classified SECRET, and should not be revealed in any manner.

    (b)   Official Agency engineering reports and photographs associated with this antenna work should not be released.

25X1

OC-E/R+D-EP/LHG:bc (19 November 1958)   COORDINATION:

cc: R+D Subject File
    SPS
    SEB
    OC-E Chrono
    R+D Chrono
    EP Chrono

    SPS   SEB

25X1

CONFIDENTIAL

STANDARD FORM NO. 64

CONFIDENTIAL

Office Memorandum • UNITED STATES GOVERNMENT

TO : Chief, Engineering Division/OC

DATE:

FROM : Contracting Officer

SUBJECT: Contract No. 605 with [ ]
Contractor's request for approval of the
presentation of two Abstracts and Summaries
at IRE Convention in New York

25X1

ENCLOSURE: A. Abstract - A New Concept in High Frequency
Antenna Design, in duplicate.

B. Abstract - Log Periodic Feeds for
Lens and Reflectors, in duplicate.

    1. There is forwarded herewith for your action one (1)
copy of the subject Contractor's letter dated October 27, 1958,
requesting that approval be granted his office for the purpose
of presenting the above papers, identified as enclosures A & B,
at the 1959 IRE National Convention in New York City, New York.

    2. It is requested that your office review the subject
Contractor's letter dated October 27, 1958, and advise this
office by return memorandum whether your office approves or
disapproves of the Contractor's request that he be allowed to
present the above identified papers at the 1959 IRE National
Convention.

    3. Your prompt attention to this matter will be appreciated.

25X1

CONTRACTING OFFICER

Distribution:
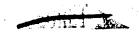 Orig & 1 - Addressee
        1 - Contract No. 605 (Official)
        1 - Chrono
        1 - Admin
        1 - Cont. Admin. (FFT)

OL/PD/CAB [ ] (6 November 1958)

25X1

CONFIDENTIAL

~~SECRET~~

CONFIDENTIAL

Chief, Engineering Division/OC

Contracting Officer

Contract No. 605 with [   ]   25X1
 Contractor's request for approval of the
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                                        CONTRACTING OFFICER

Distribution:
  Orig & 1 - Addressee
        1 - Contract No. 605 (Official)
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OL/PD/CAB:[   ] (6 November 1958)   25X1

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STAT

ABSTRACT

LOG PERIODIC FEEDS FOR LENS AND REFLECTORS

STAT

Cedar Rapids, Iowa

The application of unidirectional log periodic antennas as feeds for lens or reflectors to cover 10:1 or 20:1 bandwidths is described. Information on the primary patterns, phase center variation, input impedance, and aperture blocking of trapezoidal tooth wire and sheet structures is given so as to allow the design of feeds for a wide variety of lens and reflectors. Final results of pattern, gain and impedance measurements on two dishes over 10:1 and 20:1 bandwidths are presented and a discussion of the slight sacrifices in gain and side lobe level to achieve this bandwidth is given.

SUMMARY

LOG PERIODIC FEEDS FOR LENS AND REFLECTORS

STAT

There are many applications in the communications, search, and ECM fields where it is quite desirable to have a high gain antenna which will work over an extremely wide frequency range. Lens or reflector type antennas are often used, but their bandwidths have been limited by the primary feed. Ideally, the radiation pattern and input impedance of the primary radiator should be independent of frequency. The bandwidths of previous primary radiators have usually been on the order of 2 or 3:1. However, the recent discovery of log periodic [1,2,3,4] and angular[5] antennas with essentially frequency independent operation over bandwidths of 10 or 20:1 provides new types of wide band primary radiators. This paper presents results of an investigation of the problems involved in the application of unidirectional log periodic feeds to lens and reflector type antennas. Sufficient information on the primary patterns, phase center, input impedance and aperture blocking of trapezoidal tooth, wire and sheet log periodic structures is given to allow the antenna engineer to design feeds for a variety of lens and reflectors.

The characteristics of the primary patterns are determined by the f/d ratio, the shape, and the illumination taper of the reflector or lens aperture. Curves of the E-plane and H-plane beam widths of trapezoidal tooth wire and sheet structures as a function of the design parameters are given. The beamwidths of these unidirectional log periodic structures may be varied enough so that feeds for f/d ratios ranging from 0.3 to 0.6 are obtainable. Furthermore, independent control of the E and H plane beamwidths allows feed designs for various shapes of lens or reflectors.

Unfortunately, the phase center of unidirectional log periodic structures does not lie at the vertex or feed point. However, the phase center does lie a fixed number of wavelengths behind the vertex. That is, as the frequency is increased, the phase center moves closer and closer to the feed point. Thus, it is necessary to choose a location for the primary feed which gives optimum performance over the bandwidth. Fortunately, little gain is lost because of the phase center movement over bandwidths of 5 or 10:1. Data on the phase center variation of log periodic feeds as a function of design parameters and frequency are given. Curves showing the variation of gain with feed placement for a 4° parabolic reflector for six frequencies within the 600 to 6000 mc range are shown so as to illustrate how an optimum location is determined.

The impedance characteristics of log periodic structures in free space are such that the VSWR referred to the characteristic impedance is less than 2:1 and in many cases, less than 1.5:1. However, when the structure is placed in front of the reflector, the VSWR will be increased because of reflections from the reflector back into the feed. Curves showing the increase of VSWR as a function of reflector diameter to feed size are given.

For medium size reflectors, blocking of the aperture by the feed can become a serious problem when bandwidths of 10:1 are considered. For example, at the highest frequency the log periodic feed is ten times the minimum size required for that frequency. Measurements of the reduction of gain due to this aperture blocking are given for a 4' dish as a function of the feed antenna size. Also included are the measurements of the total scattering cross section of a log periodic antenna as a function of frequency.

Final results of pattern, gain, and impedance measurements on two dishes over 10:1 and 20:1 bandwidths are presented and a discussion of the slight sacrifices in gain and side lobe level to achieve this bandwidth is given.

[1] R. H. DuHamel and D. E. Isbell, "Broadband Logarithmically Periodic Antenna Structures", 1957 IRE National Convention Record, Part I, pp. 119-128.

[2] D. E. Isbell, "Non-Planar Logarithmically Periodic Antennas", University of Illinois, Antenna Laboratory TR#30, Feb. 20, 1958, Contract AF33(616)-3220.

[3] R. H. DuHamel and F. R. Ore, "Logarithmically Periodic Antenna Designs", 1958 IRE National Convention Record, Part I, pp. 139-151.

[4] R. H. DuHamel and D. G. Berry, "Logarithmically Periodic Antenna Arrays", 1958 IRE Wescon Convention Record, Part I.

[5] J. D. Dyson, "A Unidirectional Equiangular Spiral Antenna", University of Illinois, Antenna Laboratory TR#33, 10 July, 1958, Contract A.F. 33(616)-3220.

Communications Eng.

ABSTRACT

A NEW CONCEPT IN HIGH FREQUENCY ANTENNA DESIGN

STAT

The application of unidirectional, wire, trapezoidal tooth, log periodic antennas to H.F. point to point communications is described. The antennas are placed over ground in such a manner that the vertical plane radiation pattern as well as the other patterns and input impedance are essentially independent of frequency over the 3 - 30 mc range. Moreover, the design parameters can be chosen so that the beam direction will fall at any vertical angle from $60°$ down to a few degrees. The antennas are horizontally polarized with azimuthal beamwidths of $60°$, side lobes less than 15 db and gains ranging from 8 db to 18 db over an isotrope. These antennas should lead to considerable simplification and area reduction of antenna farms.

SUMMARY

A NEW CONCEPT IN HIGH FREQUENCY ANTENNA DESIGN

STAT

This paper describes a new type of antenna system which is ideally suited for point to point communication utilizing HF sky wave propagation. Long distance communication in the 3 - 30 mc range is effected by reflection or refraction from the ionosphere. The vertical angle of arrival (or departure) is determined by the distance between the two points, the number of hops, and the height of the ionized layer which produces the reflection or refraction. For distances less than 4000 kilometers, only one hop usually takes place. The height of the reflecting layer may lie between 100 and 400 kilometers depending upon whether the E, F, F_1, or F_2 layer is used. Thus, the desired vertical angle, ψ, may vary from some minimum value $2/3\ \psi_o$ to a maximum value somewhat less than $4/3\ \psi_o$ as the condition of the ionosphere changes from day to night through the sunspot cycle. ψ_o is chosen to be the average value of the minimum and maximum values of ψ. In addition, the operating frequency must be changed over a 4 or 5 to 1 frequency band during the sunspot cycle in order to secure reliable communications. Depending upon the distance between points, the desired vertical angle may range from approximately 60° down to only a few degrees. Thus, the ideal antenna for a point to point HF circuit should have frequency independent radiation patterns and input impedance with the beam max. at the vertical angle ψ_o. The vertical plane beamwidth between the 3 db points should be approximately ψ_o.

Present day antennas such as the rhombic, V, billboard, dipole, etc. fall far short of meeting these objectives, especially with regard to pattern band-

width. The uni-directional, wire, trapezoidal tooth, logarithmically periodic antennas which have been developed[1,2] in recent years come very close to satisfying all of these objectives. These antennas have electric characteristics which are essentially independent of frequency over extremely wide bandwidths, that is, on the order of 10 or 20 to 1. It has been found that the phase center of log periodic antennas are located a fixed number of wave lengths from their feed point, i.e., the distance from feed point to phase center measured in wave lengths is constant. As a consequence of this phenomenon when these antennas are placed at an angle with respect to ground and with their feed point at the ground level the distance from ground to the antenna phase center measured in wavelengths is independent of frequency. The vertical plane pattern of antenna and ground system is therefore independent of frequency (to the same degree that the ground conductivity and dielectric constant are independent of frequency) with the beam maximum occurring at an elevation angle determined by the angle at which the antenna is inclined to the ground.

Design information is given so that a log periodic antenna may be constructed to produce a beam direction with a vertical angle ranging from 60° down to a few degrees over any desired bandwidth in a HF range. This information is given in the form of free space radiation patterns and phase center characteristics as a function of the design parameters α, ψ and τ (refer to Reference 1 for a definition of these parameters). The results of the calculations of radiation patterns and gain of these structures when placed over ground are also given. It is shown that three basic log periodic designs (the designs have various values of α, ψ and τ) will cover nearly all point to point applications. The required frequency range determines the size of the structure; that is, the structure to cover the frequency range of 10 - 30 mc

would only be half as large as that to cover the range of 5 - 30 mc. The tower heights which support the structure are easily determined once the desired vertical angle is specified. Fortunately, the vertical plane beamwidth is approximately equal to the vertical angle of the beam maximum. Typical characteristics are horizontal polarization, azimuthal beamwidth of 60°, side lobe level 15 db down, and gains ranging from 8 db to 18 db over an isotropic antenna. Although the gains are not as high as those for some other antennas, e.g. a rhombic, the maximum gain of the log periodic antenna is utilized over an extremely wide frequency range which is not the case for a rhombic.

The wire log periodic structures are supported between fiber glass rope or steel cable and insulator catenaries which are in turn supported by steel towers.

For point to point distances greater than 4000 kilometers, the vertical angle of arrival will be less than 10 or 12 degrees regardless of the number of hops in the path. For this situation, a log periodic structure can be used to give a beam maximum at a vertical angle of 10° or somewhat less. The design of the structure for a very small vertical angle such as 2 or 4 degrees usually leads to uneconomical tower heights.

[1] R. H. DuHamel and F. R. Ore, "Logarithmically Periodic Antenna Designs," 1958 I.R.E. Convention Record, Part I, pp. 139-151.

[2] R. H. DuHamel and D. G. Berry, "Logarithmically Periodic Antenna Arrays", CTR-206, September 22, 1958.